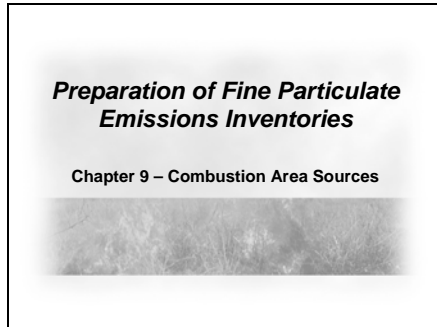


Chapter 9 – Combustion Area Sources

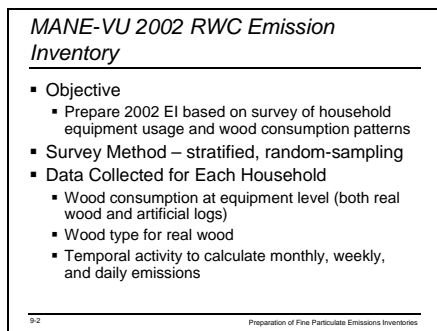
9 - 1



After this lesson, participants will be able to:

- Describe the methodologies for calculating emissions from residential wood combustion, residential and land clearing debris burning, agricultural field burning, and wildland fires.

9 - 2



The MANE-VU View Regional Planning Organization conducted a residential wood combustion survey to develop an emissions inventory for the year 2002.

A survey is the EIIP preferred method for this category.

The objective of the MANE-VU project is to prepare a 2002 inventory based on a survey of household equipment usage and wood consumption patterns, using a stratified random sampling approach.

The data collected for each household consists of:

- wood consumption at the equipment level for both real wood and artificial logs;
- the type of real wood; and
- the temporal activity to calculate monthly, weekly, and daily emissions.

9 - 3

Sample Frame Construction

- Sampling designed to address major sources of variability in activity (i.e., wood consumption)
- Sources of variability include:
 - Location and type of housing
 - Heating demand (expressed as heating degree days (HDDs))
 - Availability of wood

9-3 Preparation of Fine Particulate Emissions Inventories

The sampling was designed to address major sources of variability in wood consumption activity.

These sources include:

- the location and type of housing;
- the heating demand expressed as heating degree days; and
- the availability of wood.

9 - 4

Sample Frame Construction (cont.)

- Sample Stratification
 - Housing Data – 2000 Census tract data used to stratify sample by:
 - Urban, suburban, and rural single-family and “other” homes (other homes = multi-family units such as apartments, condos, mobile homes)
 - Rural category stratified by forested and non-forested areas using USGS GIS data (i.e., Forest Fragmentation Index Map of North America)
 - Heating Demand – Total annual HDDs used to stratify sample into 3 zones

9-4 Preparation of Fine Particulate Emissions Inventories

Housing data from the 2000 census covers four categories:

- urban
- Suburban
- rural single family
- stratified into forested versus non-forested areas using USGS-GIS data.
- other homes
- includes multi-family units:
 - Apartments
 - condominiums
 - mobile homes

Total annual heating degree days were used to further stratify the sample into three zones:

- low,
- medium and
- high.

9 - 5

<i>Sample Frame</i>								
Geographic Zone	Rural-Forested		Rural-Non-Forested		Suburban		Urban	
	Single-Family	Other	Single-Family	Other	Single-Family	Other	Single-Family	Other
High HDD	Cell 1 61 (173)	Cell 2 61 (64)	Cell 3 61 (87)	Cell 4 61 (66)	Cell 5 61 (61)	Cell 6 61 (72)	Cell 7 61 (69)	Cell 8 61 (69)
Low HDD	Cell 9 61 (150)	Cell 10 61 (62)	Cell 11 61 (118)	Cell 12 61 (69)	Cell 13 61 (76)	Cell 14 61 (67)	Cell 15 61 (75)	Cell 16 61 (62)
Med HDD	Cell 17 61 (87)	Cell 18 61 (60)	Cell 19 61 (91)	Cell 20 61 (64)	Cell 21 61 (71)	Cell 22 61 (60)	Cell 23 61 (63)	Cell 24 61 (68)

9-5 Preparation of Fine Particulate Emissions Inventories

This slide shows a sample frame shown in a grid.

61 is the minimum sample size determined based on calculations for the precision desired from the survey

The numbers in parentheses represent the number of surveys that were actually collected or completed.

Surveys for which the respondents did not categorize correctly were removed from the sample.

9 - 6

<i>Survey Instrument</i>
<ul style="list-style-type: none"> Questionnaire developed to gather activity data for: <ul style="list-style-type: none"> Indoor equipment (fireplaces, woodstoves, pellet stoves, furnaces, and boilers) Outdoor equipment (fire pits, barbeques, fireplaces, and chimineas) Pilot survey performed to test the instrument Survey conducted using computer-assisted telephone interviewing <ul style="list-style-type: none"> Completed 1,904 surveys across all 24 cells

9-6 Preparation of Fine Particulate Emissions Inventories

The survey instrument is a questionnaire developed to gather the activity data on indoor equipment and outdoor equipment.

A pilot survey was conducted to test the questionnaire.

Questions were rephrased in order to collect the information that was needed to characterize the activity.

The final survey was conducted using computer-assisted telephone interviewing.

Completed over 1,900 surveys across all 24 cells

9 - 7

<i>Survey Data Reduction/Analysis</i>	
<ul style="list-style-type: none"> QA reviewed each survey Calculated/summarized for each cell: <ul style="list-style-type: none"> User fraction (fraction of total household population that burns wood in indoor and outdoor equipment) Annual activity (cords of wood by equipment and wood types) Temporal data Conducted statistical analyses to identify significant differences between cells for: <ul style="list-style-type: none"> User fraction Annual Activity 	
9-7	Preparation of Fine Particulate Emissions Inventories

Surveys were quality assured to make sure that the data collected made sense.

Cell summaries included:

- the user fraction,
- the annual activity, and
- temporal data.

Statistical analyses identified significant differences between cells:

- the user fraction
- annual activity

9 - 8

Indoor Wood-Burning Equipment Preliminary Survey Results (% Burners)								
Geographic Zone	Rural-Forested		Rural-Non-Forested		Suburban		Urban	
	Single-Family	Other	Single-Family	Other	Single-Family	Other	Single-Family	Other
High HDO	Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8
	PP=34	PP=75	PP=42	PP=33	PP=36	PP=5	PP=30	PP=100
	WB=67	WB=75	WB=76	WB=67	WB=44	WB=0	WB=30	WB=0
	FIB=21	FIB=0	FIB=7	FIB=0	FIB=18	FIB=0	FIB=0	FIB=20
Low HDO	PP=4	PP=0	PP=0	PP=0	PP=0	PP=0	PP=0	PP=0
	Cell 9	Cell 10	Cell 11	Cell 12	Cell 13	Cell 14	Cell 15	Cell 16
	PP=65	PP=100	PP=61	PP=50	PP=35	PP=42	PP=30	PP=100
	WB=0	WB=0	WB=54	WB=50	WB=35	WB=0	WB=10	WB=0
Mid HDO	FIB=3	FIB=0	FIB=4	FIB=0	FIB=0	FIB=0	FIB=0	FIB=0
	PP=2	PP=0	PP=4	PP=0	PP=5	PP=33	PP=0	PP=20
	Cell 17	Cell 18	Cell 19	Cell 20	Cell 21	Cell 22	Cell 23	Cell 24
	PP=55	PP=60	PP=59	PP=100	PP=31	PP=30	PP=100	PP=0
	WB=66	WB=60	WB=45	WB=0	WB=27	WB=30	WB=0	WB=0
	FIB=7	FIB=0	FIB=0	FIB=0	FIB=4	FIB=0	FIB=0	FIB=0
	PP=7	PP=0	PP=9	PP=25	PP=4	PP=0	PP=0	PP=0
	PP=0	PP=0	PP=0	PP=0	PP=0	PP=0	PP=0	PP=0

PP = fireplace; WB = woodstove; FIB = furnace/boiler; PS = pellet stove. Totals do not always add to 100 since some respondents use more than one type of equipment. Values in **bold italics** are derived from responses that were identified as wood consumption outliers (equipment could be mis-categorized by the respondent).

9-8 Preparation of Fine Particulate Emissions Inventories

This table is the same table that was shown on an earlier slide with the exception that the grid cells have the fraction of indoor wood burning equipment on a percentage basis.

Observations:

- In some cases the fractions add up to more than 100% because some houses were using more than one piece of equipment.
- Rural forested areas within a high heating demand zone have a higher diversity of equipment.
- More rural households are using wood burning equipment than the urban areas.

9 - 9

<i>Preliminary Results/Observations</i>	
<ul style="list-style-type: none"> ▪ Indoor Equipment <ul style="list-style-type: none"> ▪ Geographic distribution of equipment <ul style="list-style-type: none"> ▪ Rural Areas: <ul style="list-style-type: none"> • Higher diversity of equipment types than in urban areas • Higher percentage of stoves and furnaces than in urban areas ▪ Urban/Suburban Areas: <ul style="list-style-type: none"> • Lower diversity of equipment types than in rural areas • Higher percentage of fireplaces than in rural areas ▪ Heating Demand <ul style="list-style-type: none"> ▪ High HDD Zone: <ul style="list-style-type: none"> • Rural Areas – higher percentage of stoves and furnaces ▪ Low HDD Zone: <ul style="list-style-type: none"> • Rural Areas – higher percentage of fireplaces 	
9-9	Preparation of Fine Particulate Emissions Inventories

Rural areas have a higher percentage of stoves and furnaces and boilers than urban areas.

Urban and suburban areas:

- lower diversity of equipment types
- higher percentage of fireplaces

Rural areas:

- higher percentage of stoves and furnaces in the higher HDD zone
- higher percentage of fireplaces in the lower HDD zone

9 - 10

<i>Preliminary Results/Observations (cont.)</i>	
<ul style="list-style-type: none"> ▪ Indoor Equipment <ul style="list-style-type: none"> ▪ For urban areas, it was difficult to find households that burned wood for the sample size taken ▪ The urban sample size was not increased because of budget constraints and priorities for obtaining a representative sample for three instead of two HDD zones ▪ The equipment- and fuel-based survey results were used to estimate emissions (e.g., lb PM_{2.5}/household-yr) for each household surveyed ▪ A household-based statistical model is being developed to estimate emissions for each cell 	
9-10	Preparation of Fine Particulate Emissions Inventories

For indoor equipment, because of the sample size of the survey, it was hard to find households that burned wood in urban areas.

Urban sample size was not increased for two reasons:

- Budget, and
- Priorities.

As a result, emissions were not calculated for each piece of indoor equipment in urban areas.

Equipment and fuel-based survey results were used to estimate average emissions.

Household-based statistical model was used to estimate emissions for each cell for indoor equipment.

9 - 11

Preliminary Results/Observations (cont.)

- Outdoor Equipment
 - Equipment-based emissions will be estimated using survey results

Annual Emissions = Fraction of outdoor equipment users per cell x annual activity x emission factor

9-11 Preparation of Fine Particulate Emissions Inventories

Emissions were estimated for outdoor equipment using the survey results.

The emissions are the product of:

- the fraction of outdoor equipment users per cell,
- the annual activity, and
- the emission factor.

This is the first attempt to estimate emissions from outdoor wood burning equipment at the household level.

NEI only includes indoor equipment.

9 - 12

Emission Inventory Development

- Emissions were:
 - Estimated for all criteria pollutants/precursors and several dozen toxic air pollutants
 - Estimated at the census tract level (summed to county, State, region)
 - Temporally allocated to support modeling using profiles developed from the survey

9-12 Preparation of Fine Particulate Emissions Inventories

Emissions were estimated for:

- criteria pollutants and precursors, and
- several dozen toxic air pollutants.

They were estimated at census tract level

Summed to the county, state and region.

Emissions were temporally allocated to support modeling using profiles that were developed from the survey.

9 - 13

Lessons Learned

- Survey Instrument: for regional surveys, tailor it to suit the usage patterns in rural, suburban, urban areas
- Difficult to find wood burners in urban areas – minimum sample sizes need to reflect this

9-13 Preparation of Fine Particulate Emissions Inventories

A number of lessons were learned from the MANE-VU study:

Survey instrument for regional surveys should be tailored to suit the usage patterns on rural and suburban and urban areas.

It is difficult to find wood burners in the urban areas, and the sample size may need to be increased to locate these sources.

9 - 14

Lessons Learned (cont.)

- For indoor equipment, to keep resources manageable:
 - Consider the use of a statistically-derived emissions-based model (household level) instead of an equipment-specific method
 - Concern: Approach aggregates emissions for different types of wood burning equipment needed to support control measure analysis

9-14 Preparation of Fine Particulate Emissions Inventories

For indoor equipment, keep resources manageable.

Consider the use of statistically derived emissions based model (household level) instead of an equipment specific method.

The concern with this MANE-VU approach is that it aggregates emissions for different types of wood burning equipment.

Should be disaggregated in order to conduct a control strategy analysis.

9 - 15

Documentation for MANE-VU EI

- Technical memoranda and Work Plan for a Survey to Determine Residential Wood Combustion and Open Burning Activity (July 31, 2001)
(MANE-VU Web Site:
<http://www.manevu.org/pubs/index.asp>)

9-15 Preparation of Fine Particulate Emissions Inventories

Documentation for the MANE-VU project can be obtained at the web address listed here.

Technical memoranda

Work plan including equations for calculating the sampling precision

9 - 16

How are RWC Emissions Estimated in the '02 NEI?

- SCCs
 - FIREPLACES
 - 2104008001 Without Inserts
 - 2104008002 With Inserts; Non-EPA Certified
 - 2104008003 With Inserts; Non-Catalytic, EPA Certified
 - 2104008004 With Inserts; Catalytic, EPA Certified
 - WOODSTOVES
 - 2104008010 Non-EPA Certified
 - 2104008030 Catalytic, EPA Certified
 - 2104008050 Non-Catalytic, EPA Certified

9-16 Preparation of Fine Particulate Emissions Inventories

NEI categorization:

- Fireplaces - Four SCCs
- Woodstoves - Three SCCs

9 - 17

How are RWC Emissions Estimated in the '02 NEI? (cont.)

- Pollutants
 - PM10-PRI, PM25-PRI, NO_x, CO, VOC, SO_x
 - HAPs (number of pollutants)

9-17 Preparation of Fine Particulate Emissions Inventories

NEI pollutants for residential wood combustion:

- PM₁₀ primary
- PM_{2.5} primary
- NO_x
- CO
- SO_x
- HAPs.

The emission factors that are used for residential wood combustion represent primary emissions.

There is no breakout of the filterable and condensable portions of the emission factor.

9 - 18

Emission Factors for Fireplaces Without Inserts (lbs pollutant/ton of dry wood)

- NO_x, SO_x, VOC, & HAPs
 - AP-42, Chapter 1.9, Table 1.9-1
- PM10-PRI, PM25-PRI, & CO
 - Houck, J.E., et al, "Review of Wood Heater and Fireplace Emission Factors," NEI Conference, May 1-3, 2001
 - Based on test data more current than AP-42
 - PM25-PRI assumed to be same as PM10-PRI

9-18 Preparation of Fine Particulate Emissions Inventories

The emission factors for fireplaces without inserts obtained from AP-42 except:

- PM and CO obtained from the reference listed on this slide.
- The PM_{2.5} emission factor assumed to be the same as PM₁₀ primary emission factor.

Emission factors for all pollutants from woodstoves and fireplaces without inserts are obtained from AP-42.

9 - 19

Emission Factors for Woodstoves & Fireplaces With Inserts (lbs pollutant/ton of dry wood)

- Criteria Pollutants: AP-42, Chapter 1.10, Table 1.10-1
 - PM10-PRI, PM25-PRI, & CO EFs are average for all woodstoves
 - PM25-PRI assumed to be same as PM10-PRI
- HAPs: AP-42, Chapter 1.10, Tables 1.10-2, -3, & -4
 - AP-42 EFs for Polycyclic Aromatic Hydrocarbons (PAH) reduced by 62% based on recent test data (Houck, et al, 2001)
- Conversion Factor: One cord of wood equals 1.163 tons

9-19 Preparation of Fine Particulate Emissions Inventories

This slide shows the information for emission factors for woodstoves and fireplaces with inserts.

9 - 20

Activity Data

- Develop separate national wood consumption estimates for fireplaces with inserts, fireplaces without inserts, & woodstoves to account for:
 - Different emission factors
 - Different usage patterns (climate zones; urban vs. rural)
- National wood consumption estimated using:
 - Number of combustion units
 - Average wood consumption rates
- Spatial allocation of wood consumption to county level performed to reflect usage patterns

9-20

Preparation of Fine Particulate Emissions Inventories

To account for the different emission factors and different usage patterns, the NEI developed separate national wood consumption estimates and emission estimates for:

- fireplaces with inserts,
- fireplaces without inserts,
- and woodstoves.

The methodology is different for fireplaces without inserts than it is for fireplaces with inserts and woodstoves.

9 - 21

Estimating Emissions from Fireplaces Without Inserts

- Step 1: Determine national number homes with usable fireplaces (with and without inserts)
 - Reference: Table 2-25 of 2001 American Housing Survey (AHS) for the United States (U.S. Census Bureau)
- Step 2: Adjust to account for homes with more than one fireplace (multiply Step 1 by 1.17)
 - Reference: 1989 U.S. Consumer Product Safety Commission report

9-21

Preparation of Fine Particulate Emissions Inventories

Estimating emissions from fireplaces without inserts

Step 1: determine the number of homes with fireplaces in the United States using data obtained from the US Department of Census.

Step 2: adjust to account for the fact that some homes have more than one fireplace.

9 - 22

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 3: Adjust for fireplaces that burn wood (74% wood, 26% gas)
 - References: Industry trade associations/experts, market surveys (Houck, et al, 2001)
- Step 4: Subtract out fireplaces not being used (42% not used)
 - References: Local surveys, industry market surveys, government publications (Houck, et al, 2001)

9-22

Preparation of Fine Particulate Emissions Inventories

Estimating emissions from fireplaces without inserts

Step 3: adjust to account for the fact that not every home burns wood.

Step 4: subtract the number of fireplaces not being used.

9 - 23

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 5: Determine number of homes with usable fireplaces with inserts used for heating
 - Used to determine the number of homes with usable fireplaces without inserts
 - Reference: Table 2-4 of 2001 AHS
- Step 6: Adjust to account for homes with more than one fireplace (multiply Step 5 by 1.10)
 - Reference: 1989 U.S. Consumer Product Safety Commission report

9-23 Preparation of Fine Particulate Emissions Inventories

Estimating emissions from fireplaces without inserts

Step 5: subtract number of fireplaces with inserts.

Step 6: adjust for homes with more than one fireplace.

9 - 24

Estimating Emissions from Fireplaces Without Inserts (cont.)

- Step 7: Determine number of fireplaces without inserts used for heating and aesthetic purposes
- The amount of wood burned in each device is determined by assuming wood consumption rates
 - 0.656 cords burned /unit/year for fireplaces used for heating
 - 0.069 cords/unit/year for fireplaces used for aesthetics

9-24 Preparation of Fine Particulate Emissions Inventories

Estimating emissions from fireplaces without inserts

Step 7: Separated fireplaces without inserts into 2 categories: those used for heating and those used for aesthetics.

The amount of wood burned in each device is determined by assuming wood consumption rates:

- 0.656 cords burned /unit/year for fireplaces used for heating and
- 0.069 cords/unit/year for fireplaces used for aesthetics.

9 - 25

Estimating Emissions from Fireplaces Without Inserts (cont.)

- In 1997, EPA estimated that 2.94 million cords of wood were burned in the former and 0.483 million cords of wood were burned in the latter

9-25 Preparation of Fine Particulate Emissions Inventories

In 1997, EPA estimated:

- 2.94 million cords of wood were burned for heating
- 0.483 million cords of wood were burned for aesthetics

9 - 26

<i>Spatial Allocation of National Residential Wood Consumption to Counties</i>	
<ul style="list-style-type: none"> National activity is allocated to counties using: <ul style="list-style-type: none"> Climate zone (i.e., temperature) Demographics/population (i.e., number of single-family homes) Usage patterns for each device (i.e., urban versus rural) 	
9-26	Preparation of Fine Particulate Emissions Inventories

Calculated consumption is allocated to counties based on:

- 1 of 5 climate zones,
- demographics/population, and
- usage patterns.

9 - 27

<i>Spatial Allocation of National Residential Wood Consumption to Counties (cont.)</i>	
<u>Climate Zone Consumed</u>	<u>Percent of Wood</u>
1 (>7000 HDD)	36
2 (5500-7000 HDD)	19
3 (4000-5499 HDD)	21
4 (<4000 HDD and <2000 CDD)	15
5 (<4000 HDD and >2000 CDD)	9
9-27	Preparation of Fine Particulate Emissions Inventories

Climate zones defined by:

- ranges of heating degree day and cooling degree day values
- amount of national consumption allocated to each zone

9 - 28

<i>Spatial Allocation of National Residential Wood Consumption to Counties (cont.)</i>		
<ul style="list-style-type: none"> Urban/Rural Apportionment <ul style="list-style-type: none"> Designate each county as either urban or rural, sum activity for climate zone, and adjust county activity so climate zone total matches the following proportions : 		
	<u>Rural</u>	<u>Urban</u>
Woodstoves	65%	35%
Fireplaces with inserts	43%	57%
Fireplaces without inserts	27%	73%

The census data classifies counties as either urban or rural.

Urban = 50 percent of the county's population located in cities and towns

Rural = less than 50 percent of the population located in cities and towns

The total wood consumption for all the urban counties are summed for each climate zone, and the same is done for the rural counties.

The data is adjusted if the percentage proportion between urban and rural areas does not match the percentage in the number of units that are reported in the 2001 census.

For example, if the total wood consumption for woodstoves in climate zone 1 is 60 percent for rural and 40 percent for urban, then each urban and rural county within zone 1 receives a percent increase or decrease in cordwood consumption to obtain the correct percent split to reach the 65 percent rural and 35 percent urban split for zone 1.

Finally, AP-42 factors are used to determine county emissions from fireplaces without inserts.

9 - 29

*Estimating Emissions from Fireplaces
With Inserts and Woodstoves*

- Determine the number of woodstoves and fireplaces with inserts
 - Data obtained from the Department of Census
- Adjust for homes with more than one stove
- Obtain total cords of wood consumed by residential section
 - Energy Information Administration (EIA)
- Adjust for use – heating or aesthetics

9-29

Preparation of Fine Particulate Emissions Inventories

Estimating emissions from fireplaces with inserts and woodstoves

Determine the number of woodstoves and inserts in the United States.

These data are obtained from the DOC. Adjust for the fact that some homes have more than one stove.

The total cords of wood consumed by the residential section for 1997 are obtained from the Energy Information Administration.

Subtract the cords of wood used in fireplaces for aesthetic purposes.

Units used for main heating purposes are considered different from units that are used for other heating purposes.

9 - 30

*Estimating Emissions from Fireplaces
With Inserts and Woodstoves (cont.)*

- Allocate to climate zones
- Allocate to individual counties
- Sum wood consumption and compare to urban/rural split

9-30

Preparation of Fine Particulate Emissions Inventories

Allocate consumption to 1 of 5 climate zones.

Within each climate zone, allocate consumption to the individual counties using the relative percent of detached single family homes in the county to the total number of detached single family homes in the entire climate zone.

After allocating to the climate zones, the wood consumption in each zone is summed and compared the urban and rural split.

The total is adjusted until the desired split is achieved.

The split is 65 percent rural and 35 percent urban.

For inserts, the split is 43/57.

9 - 31

<i>Estimating Emissions from Fireplaces With Inserts and Woodstoves (cont.)</i>	
<ul style="list-style-type: none"> Wood consumption for woodstoves and fireplaces with inserts were apportioned as follows: 	
Type of Device	Percent of Total Wood Consumption
Non-certified	92
Certified non-catalytic	5.7
Certified catalytic	2.3
<small>9-31 Preparation of Fine Particulate Emissions Inventories</small>	

Wood consumption for woodstoves and fireplaces with inserts are allocated to one of the three SCCs.

Fireplaces without inserts are recorded on one SCC.

Once the amount of wood consumed per residential wood combustion type is obtained, AP-42 emission factors are used to calculate emission estimates.

9 - 32

<i>Temporal Allocation of Residential Wood Consumption Emissions</i>	
<ul style="list-style-type: none"> Default temporal allocation profiles by climate zone <ul style="list-style-type: none"> S/L/T agencies should adjust allocations to better fit seasonal usage patterns Seasonal throughput percentages assigned to each climate zone are: 	
Climate Zone	Winter Spring Summer Fall
5	100 0 0 0
4	70 15 0 15
3	50 25 0 25
2	40 30 0 30
1	33.33 33.33 0 33.33
<small>9-32 Preparation of Fine Particulate Emissions Inventories</small>	

NEI seasonal activity is allocated by climate zone.

The seasonal throughput percentages assigned to each climate zone are listed on this slide.

Zone five is the warmest zone, so all the activity was placed into the winter category.

Summer has no activity with the NEI default method.

The activity is distributed across the seasons for zones two, three and four.

9 - 33

<i>How Can You Improve the NEI for Your Area?</i>	
<ul style="list-style-type: none"> Preferred Method: Residential Wood Survey <ul style="list-style-type: none"> Obtain locally representative information on the amount of wood fuel use specifically for woodstoves & fireplaces (with and without inserts) This will require a local survey, or activity data generated by State & local governments Reduces uncertainties in estimates associated with allocating national activity to counties Alternative Method: Census Bureau and EIA Data Method <ul style="list-style-type: none"> Use if resources are limited or emphasis is on preparing summer season inventory 	
<small>9-33 Preparation of Fine Particulate Emissions Inventories</small>	

Improving on the NEI method can be accomplished by:

- Conducting a local survey
- Allocating emissions within the seasons.

It is preferable to use local data and the preferred collection method is to do a local or statewide survey.

The EIIP provides an alternative method using census bureau data and the EIA data method.

9 - 34

How Can You Improve the NEI for Your Area? (cont.)

- Rule Effectiveness/Rule Penetration
 - Incorporate effects of S/L/T rules and level of compliance
 - NEI methodology does not account for S/L/T rules

9-34 Preparation of Fine Particulate Emissions Inventories

Any assumptions other than 100% for rule effectiveness and rule penetration should be incorporated into the emissions estimation methodology

NEI method does not account for the effect of state and local rules.

9 - 35

Comparison of MANE-VU Approach to NEI Method

- MANU-VU EI is a bottom-up methodology
- NEI is a top-down methodology
- MANE-VU EI provides for:
 - Better estimates by geographic area (rural, suburban, urban) and census tract (sub-county) level
 - Accounts for differences in housing type (single- and multi-family homes)
 - Better estimates of usage patterns based on HDDs
 - Includes outdoor equipment not included in NEI estimates
 - Provides temporal data

9-35 Preparation of Fine Particulate Emissions Inventories

The MANE-VU inventory is a bottom-up methodology.

NEI is top down.

MANE-VU:

- Provides better estimates by geographic area and census.
- Accounts for differences in housing type
- Provides better estimates of usage patterns based on heating demand.
- Includes outdoor equipment not included in the NEI estimates.
- Provides some temporal data that can be used to allocate emissions.

NEI emission estimates for residential wood combustion are generally within the ballpark of, but on the low end of the range of, emissions estimated for the MANE-VU inventory.

9-36

*Residential Wood Combustion
Case Study - Overview*

- Case Study: County level emissions inventory for residential wood combustion
 - See Case Study Number 9-1

9-36 Preparation of Fine Particulate Emissions Inventories

This hypothetical case study involves developing a local inventory using survey data and filling the data gaps with the NEI default data.

Direct student to Case Study 9-1 and discuss it with the students.

9-37

*Residential Wood Combustion
Case Study - Solution*

- Case Study: County level emissions inventory for residential wood combustion
 - See Handout 9-1

9-37 Preparation of Fine Particulate Emissions Inventories

Distribute the solutions (Handout 9-1) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

9 - 38

*Residential Open Burning
What Sources are Included?*

SCCs:

2610030000 - Residential Municipal Solid Waste (MSW) Burning
Pollutants: PM10, PM2.5, CO, NOx, VOC, SO2, 32 HAPs

2610000100 - Residential Leaf Burning
2610000400 - Residential Brush Burning
Pollutants: PM10, PM 2.5, CO, VOC, 6 HAPs

9-38 Preparation of Fine Particulate Emissions Inventories

Residential open burning includes:

- household waste burning
- yard waste burning (includes brush waste and leaf waste).

This slide lists the SCCs and the pollutants for residential open burning that are included in the NEI.

9 - 39

Residential Open Burning
NEI Methods for Residential MSW

- Activity Data (tons of waste burned)
- Step 1 - Estimate 2002 rural population by county
 - County-level rural population estimated by applying rural/urban percentages from 2000 Census data to 2002 population
- Step 2 - Multiply per capita waste factor by rural population
 - Used national average per capita waste generation factor of 3.37 lbs/person/day (noncombustibles and yard waste subtracted out).

9-37 Preparation of Fine Particulate Emissions Inventories

Developing activity data for residential municipal solid waste:

Step 1: estimate the rural population by county by applying percentages of rural and urban population from the census data.

Step 2: multiply the rural population by a per capita household waste factor of 3.37 pounds per person per day.

9 - 40

Residential Open Burning
NEI Methods for Residential MSW (cont.)

- Step 3- Estimate amount of waste burned
 - Assume 28% of total waste generated is burned
- Step 4 - Account for burning bans
 - For counties where urban population exceeds 80 percent of the total population, the amount of waste burned was assumed to be zero, therefore zero open burning assigned to these counties

9-38 Preparation of Fine Particulate Emissions Inventories

Developing activity data for residential municipal solid waste:

Step 3: estimate the amount of waste burned

Assume that 28% of the household waste generated is burned.

Step 4: account for burning bans. Ideally this is done by knowing exactly which areas have instituted a burning ban and the time period over which the ban applies.

The NEI assumes that if a county has an urban population that exceeds 80% of the total population the amount of waste burned is zero.

9 - 41

Residential Open Burning
NEI Methods for Residential Yard Waste

- Activity Data (tons of waste burned)
- Step 1 - Estimate 2002 rural population by county
 - County-level rural population estimated by applying rural/urban percentages from 2000 Census data to 2002 population
- Step 2 - Multiply per capita waste factor by rural population
 - Used national average per capita yard waste generation factor of 0.54 lbs/person/day.

9-39 Preparation of Fine Particulate Emissions Inventories

Developing activity data for residential yard waste:

Step 1: estimate the rural population by county by applying percentages of rural and urban population from the census data.

Step 2: multiply the rural population by a per capita household waste factor of 0.54 pounds per person per day.

9 - 42

Residential Open Burning
NEI Methods for Residential Yard Waste (cont.)

- Step 3 - Estimate amount of leaf, brush and grass yard waste
 - Multiply total yard waste mass by 25% to estimate leaf waste, 25% for brush waste, and 50% for grass waste
- Step 4 - Estimate amount of waste burned
 - Assume 28% of total leaf and brush waste generated is burned; assume 0% of grass is burned

9-40 Preparation of Fine Particulate Emissions Inventories

Developing activity data for residential yard waste:

Step 3: estimate the percentage of total yard waste that corresponds to leaf, brush, and grass waste.

The NEI assumed:

- 25% was leaf waste
- 25% was brush waste
- 50% was grass waste.

Step 4: estimate amount of waste burned.

Assume that 28% of the total leaf and brush waste is burned.

Assume that 0% of the grass waste is burned.

9 - 43

Residential Open Burning
NEI Methods for Residential Yard Waste (cont.)

- Step 5 - Adjust for variations in vegetation
 - Used the following ranges to make adjustments to the amount of yard waste generated per county:

Percent forested acres per county	Adjustment for yard waste generated
< 10%	Zero out
>=10%, and <50%	Multiply by 50%
>=50%	Assume 100%

9-41 Preparation of Fine Particulate Emissions Inventories

Developing activity data for residential yard waste:

Step 5: adjust to account for the variation in vegetation among the counties.

Use an estimate of the percent of the forested acres per county that was obtained from the biogenic emissions land cover database from the Biogenic Emission Inventory System.

For example, if the BEIS data indicates that a county has less than 10% forested acres, the NEI assumes that there is no yard waste generated.

9 - 44

Residential Open Burning
NEI Methods for Residential Yard Waste (cont.)

- Step 6 - Account for burning bans
 - For counties where urban population exceeds 80 percent of the total population, the amount of waste burned was assumed to be zero, therefore zero open burning assigned to these counties.

9-42 Preparation of Fine Particulate Emissions Inventories

Developing activity data for residential yard waste:

Step 6: account for burning bans in the same manner that was used for household waste.

9 - 45

Residential Open Burning
NEI Methods for Residential MSW and Yard Waste

$$E = A * EF * (1 - CE * RP * RE)$$

where: E = Controlled Emissions, lbs pollutant per year
A = Activity, tons of MSW or leaves/brush burned per year
EF = Emission Factor, lbs per ton burned
CE = % Control Efficiency/100
RP = % Rule Penetration/100
RE = % Rule Effectiveness/100

- 100% CE assumed for counties where urban population exceeds 80% of the total population
- Assumed 100% RE and RP
- All other counties, assumed 0% CE, RE, and RP

9-43 Preparation of Fine Particulate Emissions Inventories

Once the activity data is estimated for both solid waste and yard waste, emissions are calculated by the use of the equation shown here.

A 100% CE is assumed for counties that have an urban population greater than 80% of the total population.

The NEI also assumes that RE and RP are 100% for these areas.

The NEI assumes that all other counties are uncontrolled.

9 - 46

Residential Open Burning
EIIP Alternative for Yard Waste

- Identify records of burning permits or violations, coupled with data (or assumptions) on typical volumes and material composition

9-44 Preparation of Fine Particulate Emissions Inventories

The EIIP document for open burning contains an alternative approach for estimating emissions for yard waste.

This approach involves:

- obtaining records of burning permits or violations, and
- data on typical volumes and material composition.

9 - 47

Residential Open Burning
Improvements to NEI Methods

- Review EIIP Volume III, Ch. 16 Open Burning
- Obtain State/local estimates of per-capita waste generation
- Use State/local estimates for amount or percentage of waste burned
- Obtain State/local estimates of months when yard wastes are burned

9-45 Preparation of Fine Particulate Emissions Inventories

The open burning EIIP contains alternative methods for estimating activity data for this category.

Another approach is to use the NEI methodology coupled with state or local estimates of the per capita waste generation and the amount or percentage of waste burned.

Also, state/local data on the months when yard waste is burned would be an improvement.

The NEI does not make any temporal adjustment for yard waste burning.

9 - 48

*Residential Open Burning
Improvements to NEI Methods (cont.)*

- Sources
 - Solid Waste Agency
 - Air Agency
 - Health Department
 - Solid Waste Management Organization
 - Local Survey

9-48 Preparation of Fine Particulate Emissions Inventories

Some of the sources for this type of information include:

- the Solid Waste agency;
- the Air Agency;
- the Health Department;
- the Solid Waste Management agency;
- and
- the use of local surveys.

9 - 49

*Residential Open Burning
Improvements to NEI Methods (cont.)*

- Identify rules prohibiting or limiting open burning, and the organization that enforces those rules
- For areas that have burning prohibitions, consider performing rule effectiveness (RE) surveys
- Level of enforcement/compliance can be a significant variable in calculating controlled emissions
- Rule penetration (RP) to reflect duration of seasonal bans relative to annual activity profile, exempt activities

9-49 Preparation of Fine Particulate Emissions Inventories

The NEI can also be improved by obtaining better estimates of control measures that are applied to open burning.

This involves identifying the rules that limit or prohibit open burning and the organization that enforces those rules (e.g., fire marshal, health department).

For areas that have burning prohibitions, a rule effectiveness survey can be performed to estimate the compliance rate with the rule.

This is critical in rural areas where there are few complaints about open burning.

Also, rule penetration is critical since many open burning rules have exemptions that are listed (e.g., firefighting training activities, recreational campfires).

Rule penetration is also important for seasonal bans.

9 - 50

*Residential Open Burning
MANE-VU Example*

- Development of 2002 residential open burning inventory for MANE-VU States
- Multi-state RPO developed inventory following EIIP procedures

9-48 Preparation of Fine Particulate Emissions Inventories

This example examines the development of a 2002 residential open burning inventory for the MANE-VU states.

Developed by a multi-state Regional Planning Organization

Followed the procedures in the EIIP document (i.e., conducting a survey) to obtain activity data

9 - 51

*Residential Open Burning
MANE-VU Example (cont.)*

- Developed survey instrument to collect:
 - Number/percentage of households that burn waste
 - Burn frequency
 - Amount per burn
 - Seasonal Activity
- 3 separate surveys for:
 - Residential MSW
 - Brush
 - Leaf

9-49 Preparation of Fine Particulate Emissions Inventories

A survey instrument was developed to collect data on:

- the number of households burn waste,
- the burn frequency,
- the amount burned, and
- the seasonal nature of the burning.

Three separate surveys were performed:

- residential municipal solid waste,
- brush waste, and
- leaf waste.

9 - 52

*Residential Open Burning
MANE-VU Example (cont.)*

- Survey results were used to estimate emissions for each survey jurisdiction
- For non-surveyed areas, default activity data derived from survey responses were applied

9-50 Preparation of Fine Particulate Emissions Inventories

The data collected from these surveys were used to estimate:

- emissions for each survey area, and
- default activity data for those areas not included in the surveyed areas.

9 - 53

*Residential Open Burning
MANE-VU Example (cont.)*

- To estimate the mass of waste burned for residential MSW and yard waste, the following equation was used:

$$Wt = HH * Bt * M$$

where: Wt = Mass of waste burned per time period
 HH = Number of households that burn
 Bt = Number of burns per time period
 M = Mass of waste per burn

9-51 Preparation of Fine Particulate Emissions Inventories

This is the equation that was used to estimate the amount of waste burned based on the data collected from the surveys.

9 - 54

*Residential Open Burning
MANE-VU Example (cont.)*

- Developed control database to establish area-specific control efficiency (CE), rule effectiveness (RE), and rule penetration (RP)
- Performed rule effectiveness (RE) survey to determine level of compliance with state or local open burning prohibitions
- To estimate default RE values, the survey data was statistically analyzed resulting in one value for all non-surveyed areas

9-52 Preparation of Fine Particulate Emissions Inventories

A control database was developed that established area-specific control efficiency, rule effectiveness, and rule penetration.

Rule effectiveness and rule penetration can vary significantly depending on enforcement and the rule applicability.

A rule effectiveness survey was conducted to determine the level of compliance with the state or local open burning prohibitions.

This data was also used to estimate default RE values for use in the non-surveyed areas.

9 - 55

*Residential Open Burning
MANE-VU Example (cont.)*

- Emissions estimated for all criteria pollutants/precursors and several toxic air pollutants
- Emissions estimated at the census tract level (summed to county, State, region)
- Emissions temporally allocated to support modeling using profiles developed from the survey

9-53 Preparation of Fine Particulate Emissions Inventories

Using the activity data and the control information, emissions were estimated for:

- all criteria pollutants and precursors, and
- several HAPs.

The emissions were estimated at the census tract level and summed to the county, state, and regional level.

Finally, the data on the occurrence of the burning activities were used to temporally allocate the emissions to support modeling using profiles that were developed from the survey.

9 - 56

Lessons Learned

- If leaf burning is significant, perform separate surveys in targeted areas for leaf waste and brush waste burning
- Perform MSW surveys separate from yard waste surveys, instead of combined to reduce survey length
- A larger sample may have allowed for greater geographic distinction

9-54 Preparation of Fine Particulate Emissions Inventories

A number of lessons were learned from conducting the survey:

- Separate surveys should be performed in targeted areas where leaf burning is significant.
- Household waste and yard waste surveys should be performed separately simply to reduce the length of the survey.
- A larger sample may have allowed for greater geographic distinction.

9 - 57

Lessons Learned (cont.)

- Sub-county emissions estimates serve as the basis for a more spatially refined inventory
- Regional survey provides greater consistency
- Better accounting of controls results in decreased emissions relative to NEI

9-55 Preparation of Fine Particulate Emissions Inventories

A number of lessons were learned from conducting the survey:

- Sub-county emissions estimates serve as the basis for a more spatially refined inventory.
- A regional survey provides greater consistency that allows for easier comparison of emission estimates from different areas.
- Better accounting of controls results in a decrease of the NEI emissions.

9 - 58

Land Clearing Debris Burning
What Sources are Included?

SCCs:
2610000500 - Land Clearing Debris Burning
Pollutants: PM₁₀, PM_{2.5}, CO, VOC, 6 HAPs

9-56 Preparation of Fine Particulate Emissions Inventories

Land clearing debris burning is covered under SCC 2610000500.

The NEI contains emission estimates for PM₁₀, PM_{2.5}, CO, VOC, and 6 HAPs from this category.

9 - 59

*Land Clearing Debris Burning
NEI Method*

- Activity Data
- Estimate the county-level total number of acres disturbed by residential, non-residential and roadway construction
 - Used number of acres disturbed from fugitive dust construction emissions activity calculations
- Apply loading factor to number of acres to estimate the amount of material or fuel subject to burning

9-57 Preparation of Fine Particulate Emissions Inventories

The activity data for this category is the number of acres disturbed for the different types of construction categories.

Step 1: estimate of the county-level total number of acres disturbed.

Step 2: Apply loading factor to the number of acres disturbed to estimate the amount of material burned.

9 - 60

*Land Clearing Debris Burning
NEI Method (cont.)*

- Weighted, county-specific loading factors developed based on acres of hardwoods, softwoods, and grasses (BELD2 data base in BEIS)
- Multiplied average loading factors by percent contribution of each type of vegetation class to the total county land area

9-58 Preparation of Fine Particulate Emissions Inventories

Step 3: develop weighted county-specific loading factors based on the acres of hardwood, softwoods, and grasses.

Step 4: Multiply average loading factors by the percent contribution of each type of vegetation class to the total county land area.

9 - 61

*Land Clearing Debris Burning
NEI Method (cont.)*

- Average loading factors for hardwood and softwood further adjusted by 1.5 to account for mass of tree below the surface

Fuel Type	Fuel Loading (tons/acre)
Hardwood	99
Softwood	57
Grass	4.5

9-59 Preparation of Fine Particulate Emissions Inventories

Step 5: adjust average loading factors for hardwood and softwoods by an additional 1.5 to account for the mass of tree below the surface.

The emission factors presented in the table reflect this adjustment.

9 - 62

*Land Clearing Debris Burning
NEI Method (cont.)*

▪ Fuel Loading Factor Equation

$$L_w = F_h * L_h + F_s * L_s + F_g * L_g$$

where: L_w = County-specific weighted loading factor
 F_h = Fraction of county acres classified as hardwoods
 L_h = Average loading factor for hardwoods
 F_s = Fraction of county acres classified as softwoods
 L_s = Average loading factor for softwoods
 F_g = Fraction of county acres classified as grasses
 L_g = Average loading factor for grasses

9-60 Preparation of Fine Particulate Emissions Inventories

This slide shows the equation for developing the loading factors.

9 - 63

*Land Clearing Debris Burning
NEI Method (cont.)*

▪ Emission Calculation

$$E = A * LF * EF$$

where: E = Emissions, lbs pollutant per year
 A = No. of acres of land cleared per county
(residential + commercial + road construction)
 LF = County-specific loading factor, tons per acre
 EF = Emission factor, lbs pollutant per ton

- Represents an upper-bound emissions estimate
- Assume all fuel loading on land cleared is burned; no controls or bans

9-61 Preparation of Fine Particulate Emissions Inventories

Emissions are estimated from the activity data as shown by this equation.

This formula multiplies:

- the activity data,
- the number of acres of land, and
- the county-specific loading factor.

Since the loading factor does not vary by the types of construction, the number of acres cleared for all three types of activities are summed before the loading factor is applied.

The NEI assumes that all the fuel loading on the land cleared is burned and that no controls or bans are in place.

For estimating these emissions, the NEI takes a similar approach as to that used for Residential Yard Waste (see Slide 42), in that it removes emissions from counties that are considered mostly urban.

9 - 64

*Land Clearing Debris Burning
Improvements to NEI Method*

- Review EIIP section on Open Burning
 - EIIP Volume III, Ch. 16
 - Preferred methods rely on direct measure of mass of waste or debris burned
 - Mass amounts may be available from permits issued
- Improve estimates of the acres cleared
- Develop improved estimate of the "average loading factor"

9-62

Preparation of Fine Particulate Emissions Inventories

A good place to begin is to Review the EIIP section on open burning.

The EIIP methods rely on a direct measure of mass of waste or debris burned, which may be obtainable from local officials that track this activity for permitting purposes.

Also, obtaining a better estimate of the acres cleared for the fugitive dust construction category would improve the inventory for the land clearing debris burning category.

Other approaches for improving the NEI include developing an improved loading factor.

9 - 65

*Land Clearing Debris Burning
Improvements to NEI Method (cont.)*

- Identify specific counties with burning bans, and specification of counties where wastes are burned
- State or local estimates of the percentage or amount of waste burned per construction event

9-63

Preparation of Fine Particulate Emissions Inventories

Other ways to improve on the NEI include:

- Identifying specific counties with burning bans and specifying counties where wastes are burned.
- Obtaining state or local estimates of the percentage or amount of waste burned per construction event (The NEI assumes that the fuel loading associated with the land that is cleared is being burned).

9 - 66

*Land Clearing Debris Burning
Northern Virginia Example*

- Performed RE survey to determine the level of compliance with rules for:
 - Land clearing debris burning
 - Residential waste burning
- Developed RE to apply to ozone season open burning emission estimates for the Virginia portion of the Washington DC-MD-VA Ozone Nonattainment Area

9-64 Preparation of Fine Particulate Emissions Inventories

This Northern Virginia area study involved a RE survey to determine the level of compliance with rules for land clearing debris burning and residential waste burning.

The objective of the study was to develop a defensible RE value for use in the State Implementation Plan.

Current EPA guidelines requires the application of an 80% rule effectiveness.

9 - 67

*Land Clearing Debris Burning
Northern Virginia Example (cont.)*

- Reviewed conditions of existing open burning rules
 - Time period of ban
 - Exemptions and special provisions
- Surveyed local open burning officials responsible for tracking and enforcing open burning rules

9-65 Preparation of Fine Particulate Emissions Inventories

The study reviewed the existing conditions of the open burning rules to determine:

- the time period of the ban, and
- the exemptions that apply.

A survey of local open burning officials responsible for tracking and enforcing open burning rules was conducted.

9 - 68

*Land Clearing Debris Burning
Northern Virginia Example (cont.)*

- Started with EPA questionnaire from RE guidance, modified for open burning
- Responses to questions are assigned specific point values that add up to a maximum of 100 points, considered equivalent to a RE percentage value

9-66 Preparation of Fine Particulate Emissions Inventories

The survey form was derived from an EPA questionnaire that is available from the rule effectiveness guidance.

Responses to the questions on the survey were assigned a specific point value that adds up to a maximum of 100 points.

This point value is considered equivalent to the RE percentage value.

If all the questions were answered with the highest rating, an RE value of 100% was assigned.

9 - 69

*Land Clearing Debris Burning
Northern Virginia Example (cont.)*

- RE values analyzed by county and for 5-county region
 - Estimated regional RE of 93 percent
- If area comprised of counties and jurisdictions with significantly different population densities, analyze responses by urban and rural areas

9-67 Preparation of Fine Particulate Emissions Inventories

The RE values were analyzed by county as well as for the five-county region.

A regional RE value of 93% was estimated.

Although not done in this case study, separate RE values could be developed for urban and rural area in cases where there are significantly different population densities.

9 - 70

Lessons Learned

- Local officials may defer to higher officials (e.g., county or state-level) for enforcing open burning rules
- RE may be high for time period that ban is in effect, but need to account for duration of ban (RP) if less than annual or seasonal
- It is important to account for when the ban is taking place

9-68 Preparation of Fine Particulate Emissions Inventories

Some of the lessons learned from this study are:

- Local officials tend to defer to the county or state level officials for enforcing the open burning rules.
- In developing an annual emissions inventory, it is important to note that RE may be high only for the time period that the ban is in effect.
- The duration of the ban needs to be taken into account if it is less than annual or seasonal.

Account for when the ban is taking place and if it overlaps with when the activity occurs.

For example, a ban in place for the summer months for brush waste burning will have minimal impact if the majority of the brush burning occurs in the fall.

9 - 71

<i>Agricultural Burning - Overview</i>	
<ul style="list-style-type: none">▪ SCC 2801500000▪ PM10-PRI and PM2.5-PRI▪ Both condensibles and filterables	
9-69	Preparation of Fine Particulate Emissions Inventories

Agricultural burns create particulate matter pollution and their inventory is important to the overall particulate matter air quality analysis.

The SCC for agricultural burning is 2801500000.

EPA encourages States to inventory both PM10 and PM2.5-PRI.

Since agricultural burning is a combustion process, both condensibles and filterables are included in the PM-PRI estimate.

9 - 72

<i>Agricultural Burning - General Method</i>	
<ul style="list-style-type: none">▪ Activity<ul style="list-style-type: none">▪ Acres of crop burned▪ Loading Factor (tons of biomass or vegetation per acre burned)▪ Emission Factor<ul style="list-style-type: none">▪ Pounds PM_{2.5} per ton of vegetation burned (crop-specific)	
9-70	Preparation of Fine Particulate Emissions Inventories

EPA develops emission estimates for most source categories in the NEI and States submit any improved information that they have for those particular categories.

EPA does not at this time prepare an estimate of emissions from agricultural burning.

EPA encourages each State to develop their own inventories and submit them.

In 1999 ten States (Alabama, California, Delaware, Georgia, Idaho, Kansas, Maine, Oregon, Texas, and Utah) developed their own agricultural burning inventory.

In general, these States developed the inventories by:

- characterizing the activity or acres of the crop burned,
- the loading factor, and
- the emission factor.

9 - 73

Wheat Stubble Burning Example

- Method - Develop inventory using county-specific data when available
 - Activity
 - Acres of wheat burned by month obtained from burn permits issued by county fire department
 - Fuel loading for wheat stubble from county agricultural extension office

9-71 Preparation of Fine Particulate Emissions Inventories

This study involves wheat stubble burning and uses county-specific data.

The activity data that was obtained are the acres of wheat burned by month.

This was obtained from burn permits that are usually issued by the county fire department.

The fuel loading for wheat stubble was obtained from the county agricultural extension office.

9 - 74

Wheat Stubble Burning Example (cont.)

- Emission Factors
 - PM10: 8.82 pounds per ton of wheat stubble burned
 - PM2.5: 8.34 pounds per ton of wheat stubble burned
- Resolution
 - Spatial – county
 - Temporal – monthly

9-72 Preparation of Fine Particulate Emissions Inventories

The emission factors are from a study done by CARB

(Jenkins, B.M. et al., *Atmospheric Pollutant Emission Factors from Open Burning of Agricultural and Forest Biomass by Wind Tunnel Simulations*, Volume 2, Results, Cereal Crop Residues, California Air Resources Board Project Number A932-126).

The spatial resolution = county

The temporal resolution = monthly.

9 - 75

Wheat Stubble Burning Example (cont.)

- Sample Calculation
 - PM2.5-PRI Emissions
 - = Acres Burned per month * Loading Factor * Emission Factor

Annual PM2.5-PRI Emissions = ? Monthly Emissions

9-73 Preparation of Fine Particulate Emissions Inventories

This slide shows the formula for calculating PM2.5-PRI emissions.

This calculation would be repeated for each month during the burning season and summed to give an annual emissions estimate.

9 - 76

Agricultural Burning - Improvements

- Preferable to inventory larger fires (> 100 acres) as events with a start and stop date and time; lump smaller fires into monthly acreages
- Requires coordination with burners and permit authorities
- Start building a system and relationships with the burners/ permitting authorities to enable such an inventory in the future

9-74 Preparation of Fine Particulate Emissions Inventories

EPA encourages all states to develop their own agricultural burning inventory.

For fires larger than 100 acres, EPA suggests:

- locate at a specific latitude and longitude, and
- record stop and start date and time of the fire.

Smaller fires should be lumped into overall monthly acreage like in the previous case study example.

Obtaining information on agricultural burning requires coordination with the burners and the permitting authorities.

In order to develop an agricultural burning inventory, states need to build a system and a relationship with the burners and permitting authorities.

Chances are pretty good that the first time a State tries to obtain this information they will find that records are not kept or are not kept in a way that can easily be understood.

9 - 77

*Agricultural Burning - Improvements
(cont.)*

- Obtain local acres of crops burned data from:
 - Burn permits
 - Survey of county agricultural extension offices
- Verify that burns actually occurred
- Obtain fuel loading data
 - Local data preferred from county agricultural extension offices, local Natural Resources Conservation Service Center
 - National defaults available from Chapter 2.5 in AP-42

9-75

Preparation of Fine Particulate Emissions Inventories

The local acres of crops burned are obtained from:

- burn permits,
- a survey of county agricultural extension offices, or
- a combination of both.

It is important that States verify that the burns actually occurred.

Often a burner will get a permit to burn a lot more acreage than they actually are able to burn in a particular day.

In many cases a burner is limited by the weather or other factors that keep them from burning the acreage that they are permitted to burn.

States need to obtain local fuel loading data.

Obtainable from the local county agricultural extension office or the local Natural Resources Conservation Service Center.

Preferable to using the national defaults that are available in Chapter 2.5 of AP-42.

9-78

*Agricultural Burning
Case Study - Overview*

- Case Study: County level emissions inventory for burning of wheat stubble
 - See Case Study Number 9-2

9-78 Preparation of Fine Particulate Emissions Inventories

This hypothetical case study involves developing a local inventory using survey data and filling the data gaps with the NEI default data.

Direct student to Case Study 9-2 and discuss it with the students.

9-79

*Agricultural Burning
Case Study - Solution*

- Case Study: County level emissions inventory for burning of wheat stubble
 - See Handout 9-2

9-79 Preparation of Fine Particulate Emissions Inventories

Distribute the solutions (Handout 9-2) to the case study. Review each question with the students. Encourage discussion among the class. Ask each group to report on the questions that were assigned to them. Ask the other groups to critique their responses.

9 - 80

Overview of Wildland Fire Inventory

- Wildland Burning
 - Types: Wildfires, Managed (Prescribed) Burns
 - Burners:
 - NPS, USFS, BLM, USFWS, State & Tribal Forests, Private burners
- Prescribed Burning
 - Habitat improvement
 - Managing undergrowth and understoring of the forest
 - Reducing risk of wildfires

9-78 Preparation of Fine Particulate Emissions Inventories

Fires have become a major issue in:

- visibility impairment
- creation of high concentrations of PM_{2.5} that could result in health problems.

The problems have been mainly in the West, but also wildfires from the Southeast, the Central States, Canada, and Mexico have become a concern.

EPA's wildland burning inventory includes both wild and managed burns.

The typical agencies that burn are:

- the National Park Service,
- the United States Forest Service,

- the Bureau of Land Management,
- the United States Fish and Wildlife Service,
- State & Tribal Forests, and
- private burners.

Prescribed burns are those burns that are ignited intentionally:

- for habitat improvement of the wildlife;
- for managing the overall under growth and understoring of the forest; and
- to reduce the risk of wildfires later on by removing the fuels from the forested area.

9 - 81

How were Wildfire Emissions Estimated in the '99 – '02V1 NEI?

- Pollutants
 - PM₁₀, PM_{2.5}, NO_x, CO, VOC, SO₂, 30 HAPS
- Emission Factors (AP-42)
- State-specific fuel consumed per acre burned
- Annual Activity Data ~ State (or regional) level
 - USFS, BIA, BLM, NPS, FWS
 - Some States provide private / State burn data
 - Spatial allocation to counties using forested area
- Emissions Processor ~ Allocates Diurnal & Monthly

9-77

Preparation of Fine Particulate Emissions Inventories

The approach used to estimate wildfire emissions in the NEI is a very rudimentary approach.

It should be noted that this discussion focuses on the technique for estimating emissions from wildfires; however, emissions from prescribed or managed fires are estimated in a similar fashion.

The pollutants that are included in the NEI inventory for wildland fire emissions are:

- PM₁₀,
- PM_{2.5},
- NO_x,
- CO,
- VOC,
- SO₂, and
- about 30 HAPS.

The emissions factors for estimating fire emissions and the state-specific fuel consumed per acre burned are found in the NEI documentation.

The technique is to merge the factor and fuel consumption information with annual activity data obtained at either the state or regional level from the main burning agencies.

Most of the federal burners keep fairly good records of the burns that they conduct mostly because these fires end up being watched and/or fought by personnel.

Some states also provide burn data as do some private burners

The data obtained from the burners is at the state level or regional level and it is allocated to the state or county level using the amount of forested area in a state.

The amount of acreage that was burned during a year in a particular state is allocated across the state to the forested lands

The NEI allocates the emissions annually and the emissions processor allocates the emissions diurnally and monthly.

This allocation is important because certain areas of the country have different fire seasons and fire seasons are different for prescribed burns and managed burns.

9-82

What are the RPO's Doing?

- The Regional Planning Organizations (RPOs) are working on:
 - Treating most fires as point sources
 - Using fire-specific fuel consumption
 - Providing a much improved emission estimate

9-78 Preparation of Fine Particulate Emissions Inventories

RPOs are working on treating most fires as point sources, using fire-specific fuel consumption, and providing a much improved emission estimate.

9-83

What are Future Plans for Improving the Approach to Estimating Fire Emissions?

- Future plans include the following:
 - Incorporate satellite observations
 - Improve locational data
 - Improve fuel characterization
 - Use actual fire weather conditions that effect emissions

9-79 Preparation of Fine Particulate Emissions Inventories

Future plans include incorporating satellite observations, improving locational data, improving fuel characterization, and using actual fire weather conditions that effect emissions.

9 – 84

What Needs to Happen Nationally / Regionally to Improve Wildland Fire Emissions?

- Improve Regional / National Databases & Models
 - Fire Event: area burned, when, where
 - Develop, refine national & regional models & databases to estimate pre-burn fuel loading
 - Refine, expand use of fuel consumption models
 - Provide guidance on estimating impact of mitigation measures on emissions

9-78

Preparation of Fine Particulate Emissions Inventories

In order to improve wild land fire emissions, national and regional databases and models must be improved.

Fires need to be treated as events.

Large fires need to be entered into the databases as point sources, including:

- particular location,
- start date,
- end date, and
- the time of day.

National regional models and databases need to be developed and refined to improve the pre-burn fuel loading information.

The information in AP-42 is very general, very dated, and averaged over large regions of the country.

Use of fuel consumption models needs to be to refined and expanded.

Guidance on estimating the impact of mitigation measures on emissions needs to be provided.

9 – 85

What Needs to Happen Nationally / Regionally to Improve Wildland Fire Emissions? (cont.)

- Fire Events Database Development
 - Federal MOU
 - Includes: EPA, DOI, USDA
 - Broad Scope: Fire Management Activities
 - Status: In Progress
 - Investigation of the role of national databases
 - USDA / DOI efforts
 - NEISGEI <http://capita.wustl.edu/NEISGEI/>
 - B-RAINS (Pacific NW Database)
 - Much more work is needed to move toward real time data collection, QA & sharing

9-79 Preparation of Fine Particulate Emissions Inventories

Fire Events Database Development

There is a Memorandum of Understanding in effect between the EPA, Department of Interior, and the United States Department of Agriculture to develop a fire events database.

It is a broad scope MOU that covers fire management activities including ways to improve the national databases.

There is a similar effort called nice guy, being conducted at Washington University in St. Louis.

There currently exists a database for recording fire events in the Pacific NW called the B-RAINS system.

Although these types of projects are moving toward real time data collection, quality assurance and data sharing, there is much more work needed in these areas.

9 – 86

What Needs to Happen Nationally / Regionally to Improve Wildland Fire Emissions? (cont.)

- Investigating the Potential Use of Satellites
 - EPA
 - EIIP-funded Overview of Using Satellites in AQ
 - <http://www.epa.gov/ttn/chief/eiip/pm25inventory/remsens.pdf>
 - Collaboration w/ NASA
 - Interagency
 - NIFC
 - Work at Missoula Fire Research Center & Salt Lake City
 - Collaboration w/ NASA
 - Others
 - CAMFER

9-80 Preparation of Fine Particulate Emissions Inventories

EPA is also investigating the potential use of satellites to improve wildland fire inventories.

EPA has funded a report entitled *Overview of Using Satellites in AQ Management*.

There is also collaboration going on with NASA to take advantage of their skills in aerial surveillance with satellites.

There are several interagency groups working on the use of satellites including the National Interagency Fire Center (a jointly funded effort of all the Federal burners) in Boise, Idaho, the Missoula Fire Research Center, and Salt Lake City.

Another project includes CAMFER, which is a project underway at University of California Berkeley.

9 - 87

What Needs to Happen Nationally / Regionally to Improve Wildland Fire Emissions? (cont.)

- Emission Estimation Tools & Inventories
 - EPA
 - Recent Report: Fire Emission Estimation Methods
 - USFS
 - Work at the Fire Sciences Lab (Missoula)
 - Work at Pacific NW Research Station (Corvallis)
 - Collaboration
 - WRAP - Fire Emissions Joint Forum
 - RPO-led 2002 Wildland Fire EI development
 - Nat'l Fire Emissions Workshop
 - Nat'l FCC coverage @ 1 km² resolution
 - Emissions model to interface with grid models

9-81 Preparation of Fine Particulate Emissions Inventories

EPA recently published a report entitled *Fire Emission Estimation Methods* that is available on the CHIEF web site that contains a lot of good background information on wildland fire emission estimation.

In addition, there is a lot of ongoing work to improve emission estimation tools for wildland fires.

The US Forest Service has ongoing work on the development of fuel consumption and fire behavior models at the Fire Sciences Lab in Missoula and also at the Pacific NW Research Station in Corvallis.

Also, there is also a lot of emission factor testing occurring in the Fire Sciences Lab in Missoula.

There is also collaboration going on between all the different burn agencies, EPA, and the Regional Planning Organizations.

The Western Regional Air Partnership conducts a fire emissions joint forum and EPA and the burn agencies participate in that forum.

There is a RPO project to refine the 2002 wildland fire emissions inventory.

There was a national fire emissions workshop held in May of 2004 that focused on the latest ideas and methodologies for estimating fire emissions.

Also, the US Forest Service with assistance and funding from EPA is developing a geographic coverage of the fuel types and fuel conditions for burning at a 1km resolution.

A map of the country that will be useful in GIS systems will be developed out of this project.

Finally there will be further work on developing an emissions model that will estimate fire emissions in real time using real time meteorological data.

Output from this model will be fed directly into the grid models for estimating ambient air concentrations associated with fire emissions.

9 - 88

*Wildland Fire Emissions Module
(under development)*

- Modular input to Emission Models (e.g., SMOKE, OpEM) to interface with the CMAQ modeling system
- User Inputs: Fire locations, duration, size
- Model Components (Modules from the BlueSky system)
 - Fuel loading default: NFDRS / FCC map
 - Fuel Moisture: Calculates using MM5 met data
 - Fuel Consumption: CONSUME / FOFEM
 - Emissions, Heat Release & Plume Rise: EPM & Briggs (modified)

9-82 Preparation of Fine Particulate Emissions Inventories

The emissions model that is under development is the Wildlands Fire Emissions Model.

It will interface with SMOKE and OpEMs, and the CMAQ modeling system.

The user will need to input:

- fire locations,
- durations, and
- size of the fire.

The model components, which will be drawn from the Blue Sky system being developed in the Pacific NW, are:

- 1) A fuel loading default that will use either the national fire danger rating system or, as it becomes available, the FCC map.
- 2) Fuel moisture will be calculated using actual metrological data for the period during, and immediately before the fire.

This is a significant improvement over the past and an important improvement since fuel moisture is critical in determining the amount of fuel that will burn and the emissions from that fuel.

- 3) Fuel consumption models are being built into the model.

Both the CONSUME / FOFEM are such models that have recently been improved significantly.

The CONSUME model is developed in the Corvallis lab and the FOFEM has been developed by the Missoula Fire Lab.

These models compliment each other and have strengths and weakness that, when used together properly, give a pretty good handle on fuel consumption.

- 4) The emission heat release and plume rise is being handled through the EPM model and the modified Briggs plume rise equation.

There is an improvement to the EPM model called FAR, which is about to be released in beta test form.

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*Wildland Fire Emissions Module
(under development) (cont.)*

- Outputs: Gridded hourly emissions, plume characteristics
- Integrate, Test & Release Module (late 2004)

9-83

Preparation of Fine Particulate Emissions Inventories

The output of the model will be:

- a gridded hourly emission estimate, and
- plume characteristics.

The output will be able to be interfaced with grid models to provide a regional scale estimate of the effects of fires.

For instance, this new wildland fire model will be able to estimate the NO_x plume from a wildland fire and the effects of that increased NO_x on ozone formation.

The integration, testing, and release of the model are anticipated for late 2004.

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